

A new species of *Tamarixia* Mercet (Hymenoptera, Eulophidae), parasitoid of *Trioza aguacate* Hollis & Martin (Hemiptera, Triozidae) in Mexico

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| <http://zoobank.org/640DF66D-8B7C-428B-BA70-6A406966E95A>

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Academic editor: M. Engel | Received 21 October 2013 | Accepted 16 December 2013 | Published 7 January 2014

<http://zoobank.org/CAB95513-A8F3-4C55-8D3D-8AE8B1DD24B8>

Citation: Yefremova Z, González-Santarosa G, Lomeli-Flores JR, Bautista-Martínez N (2014) A new species of *Tamarixia* Mercet (Hymenoptera, Eulophidae), parasitoid of *Trioza aguacate* Hollis & Martin (Hemiptera, Triozidae) in Mexico. ZooKeys 368: 23–35. doi: 10.3897/zookeys.368.6468

Abstract

Tamarixia aguacatensis Yefremova, **sp. n.** (Hymenoptera: Eulophidae: Tetrastichinae) is described from Mexico as a parasitoid of the avocado psyllid, *Trioza aguacate* Hollis & Martin (Hemiptera: Triozidae). *Trioza aguacate* is a serious pest of avocado, *Persea americana* Miller. A key to the species of *Tamarixia* Mercet in Mexico is given.

Keywords

Insecta, Chalcidoidea, *Tamarixia aguacatensis*, *Trioza aguacate*, *Persea americana*, Mexico

Introduction

The Mexican fauna of Psyllidae is poorly known, and even less known there are psyllid parasitoids. At least four *Tamarixia* Mercet (Eulophidae: Tetrastichinae) species have been recorded in Mexico as psyllid parasitoids: *T. leucaenae* Bouček from *Heteropsylla cubana* Crawford (Psyllidae: Ciriacreminae), *T. triozae* (Burks) from *Bactericera cockerelli* (Sulc) (Psyllidae: Triozinae) (Burks 1943), *T. radiata* (Waterston) from *Diaphorina citri* Kuwayama (Psyllidae: Diaphorinae) (Waterston 1922), and *T. schina* Zuparko from *Calophya schini* Tuthill (Psyllidae: Calophyidae) (McClay 1990; Lomeli-Flores and Bueno Partida 2002; Alvarez-Zagoya and Cibrian-Tovar 1999; Zuparko et al. 2011).

The most studied species is *T. triozae*, which was first recorded by Lomeli-Flores and Bueno Partida (2002) from a collection on tomato crops at Michoacán with a level of parasitism of 20–85% on *B. cockerelli*. This species is common as a *B. cockerelli* parasitoid in field crops of some solanaceous plants such as tomatillo (*Physalis philadelphica* Lam.), tomato (*Solanum lycopersicum* L.), potato (*Solanum tuberosum* L.), eggplant (*Solanum melongena* L.), and peppers (*Capsicum annuum* L.). *Tamarixia radiata* was introduced to Mexico for the biological control program against *D. citri*; this parasitoid species has a wide distribution in Mexico and is now common in most Mexican citrus-growing areas (González-Hernández et al. 2009). This species is mass-reared for the augmentative biological control by Koppert México. As part of a federal program (Campaña Fitosanitaria de Prioridad Nacional contra el HLB: <http://www.senasica.gob.mx/?id=4512>) in Mexico there are two facilities designated for *T. radiata* mass rearing, one in Colima and the other one in Yucatán. In April, 2013, alone more than 465,900 parasitoids were released in the citrus areas in seven Mexican states. Elsewhere, the other two species (*T. leucaenae* and *T. schina*) were established as biological control agents of the invasive psyllids *H. cubana* in Africa and Asia (Day 1999; Rao et al. 2000) and *C. schini* in California (Zuparko et al. 2011). The latter species (*T. schina*) is now common in Mexico as a parasitoid of *C. schini* on peppertrees (*Schinus molle* L.). Apparently, this parasitoid dispersed to Mexico from California on its own, and no further studies on it have been conducted. In addition to these psyllid species as hosts of *Tamarixia*, another species of this genus was recovered from the avocado psyllid, *Trioza aguacate* Hollis & Martin (Hemiptera: Triozidae).

The avocado psyllid was discovered for the first time in Mexico in 1995, on avocado trees (*Persea americana* Miller) (Hollis and Martin 1997). This species was originally reported in Uruapan, Michoacán, and later dispersed in most of the avocado growing areas of that state. This pest affects the native Mexican avocado trees including those of the Hass variety. The main damage is caused by the nymphs. Adults deposit their eggs along the centre ribs of young leaves, and the nymphs establish themselves on the leaf ribs and on the tender stems, causing bud deformities. This species is abundant only in spring, when avocado trees develop most of the new buds. Recently, parasitoids in the host nymphs have been detected. From them a species of *Tamarixia* has been reared which does not correspond to any of the previously described taxa in the genus.

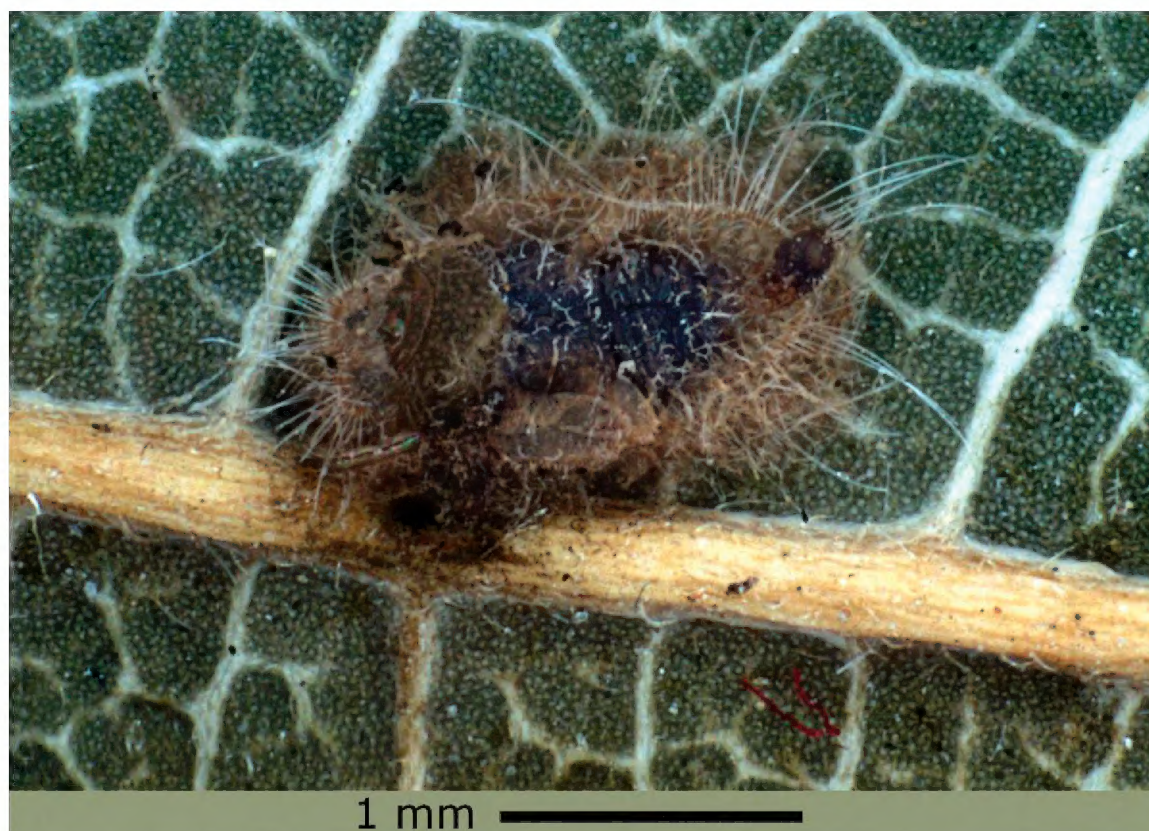


Figure 1. Mummy of *Trioza aguacate* nymph.

Material and methods

Periodic samples were taken in avocado groves in the town of Salvador Escalante, Michoacán, from January 2012 to January 2013; however, presence of the parasitoid was detected only in April and May 2012. To recover some of the parasitoids, buds and avocado leaves with parasitized nymphs of *T. aguacate* were collected; these are recognized by their ochre brown tone (Fig. 1). No more than 10 mummies per jar were collected.

The collected material was placed in glass jars covered with organza fabric to wait for the parasitoids to emerge. Overall parasitism of the nymphs was 14.6%; but when we recorded only the large nymphs the percent parasitism was 46.7%.

After the parasitoids were processed, pictures were taken of the diagnostic characteristics to compare this species with the already described species (Graham 1987; LaSalle 1994; Zuparko et al. 2011). The pictures were taken using the Scanning Electron Microscope (JEOL JSM 6390) and a stereomicroscope. Also, a sample of 36 buds was collected on 11 May 2012; the total number of nymphs and the parasitized nymphs were recorded per each 5 cm bud.

Morphological terminology follows that of Graham (1991). F1 – first segment of antennal funicle, F2 – second segment, F3 – third segment, F4 – fourth segment, C1 – first segment of clava, C2 – second segment of clava, C3 – third segment of clava; SMV – submarginal vein, MV – marginal vein, PMV – postmarginal vein, SV – stigmal vein, POL – the minimum distance between the posterior ocelli, OOL – the minimum distance between the eye margin and the adjacent posterior ocellus. Absolute measurements are given in millimetres (mm) for body and fore wing length; for other dimensions, relative measurements are used. Observations and measurements

were made using a Nikon dissecting microscope (top magnification of 63 ×) with a 100-division linear scale micrometer.

The following acronyms are used for the depositories of specimens:

- CNIN** The National Insect Collection at the Instituto de Biología, Universidad Autónoma de Mexico, Mexico City, Mexico.
- FSCA** Florida State Collection of Arthropods, Gainesville, Florida, USA.
- USNM** United States National Museum of Natural History, Washington, D.C., USA.
- TAUI** The National Collection of Insects, Zoological Museum, Department of Zoology, Tel Aviv University, Tel Aviv, Israel.

Taxonomy

Genus *Tamarixia* Mercet, 1924

<http://species-id.net/wiki/Tamarixia>

Type species. *Tamarixia bicolor* Mercet, 1924: 57 (original designation).

Diagnosis. *Tamarixia* can be distinguished by the following combination of features: fore wing with a single seta on the dorsal surface of the submarginal vein, propodeum without a Y-shaped carina; plicae and paraspiracular carinae absent, midlobe of mesoscutum with 2 pairs of long adnotaular setae (three pairs setae in *Tamarixia dahlsteni* Zuparko, 2011) and additional 2 pairs of short setae in the upper part in a horizontal row and 1 seta near notauli in *Tamarixia aguacatensis* sp. n. (Fig. 7). The anterior margin of the female hypopygium is almost straight, and the males have exceptionally long genitalia. An additional diagnostic character is that the toruli are closer to eye margin than to each other. Species are generally shiny black, but may have yellow markings on the gaster and/or head. The gaster of the female subcircular to ovate; one seta of each cercus 1.5 times or more the length of the next longest seta.

Biology. Species of *Tamarixia* are primary ectoparasitoids of psyllids (Graham 1987, 1991; Bouček 1988a, 1988b; LaSalle 1994; Brothers and Moran 1969; Moran et al. 1969; Noyes 2013) and parasitize immature stages of *Trioza* (Hemiptera, Psyllidae) (Mead 1994).

Distribution. *Tamarixia* is a cosmopolitan genus, with about 50 described species (Noyes 2013), most of them in Palearctic. Zuparko et al. (2011) listed 47 species of *Tamarixia* in the world but the authors missed 3 species: *Tamarixia krascheninnikovi* (Kostjukov, 1990), *T. fulvus* Yefremova & Yegorenkova, 2009 and *T. psyllae* Yefremova & Yegorenkova, 2009 (Kostjukov 1990; Yefremova and Yegorenkova 2009).

Identification. Keys to *Tamarixia* species are available for Europe (Graham 1991), the European part of Russia and the Far East of Russia (Kostjukov 1978; Kostjukov 1995, 2000), India (Narendran 2007), North America (Burks 1943, two species as part of *Tetrastichus*), and Yemen (Yefremova and Yegorenkova 2009).

Key to Mexican species of *Tamarixia*

(Females)

- 1 F3 subquadrate or transverse (Figs 14, 16, 19, 21), F1 1.2–1.3 times as long as F3 2
- F3 1.8–2.0 times as long as broad (Fig. 6), F1 1.45–1.5 times as long as F3 .
..... *Tamarixia aguacatensis* sp. n.
- 2 Mesoscutum with complete median line... *Tamarixia radiata* (Waterston)
- Mesoscutum with incomplete median line (Fig. 7) 3
- 3 Propodeum steeply inclined relative to longitudinal axis of the body
..... *Tamarixia schina* Zuparko
- Propodeum inclined 45 degrees from longitudinal axis of the body (Fig. 5) ... 4
- 4 F2 as long as F3, F1 2.2 times as long as broad, clava 1.3 times as long as funicle (Fig. 16) *Tamarixia triozae* (Burks)
- F2 1.4 times as long as F3, F1 1.8 times as long as broad, clava 1.5 times as long as funicle (Fig. 19) *Tamarixia leucaenae* Bouček

(Males)

- 1 Pedicel 1.5 times as long as F1 (Figs 15, 17, 20, 22) 2
- Pedicel as long as F1 or slightly longer (1.1 times as long as F1) (Fig. 8)
..... *Tamarixia aguacatensis* sp. n.
- 2 Clava 5.0 times as long as broad (Fig. 22) *Tamarixia radiata* (Waterston)
- Clava 4.0 times as long as broad 3
- 3 F2, F3 1.3–1.4 times as long as broad (Fig. 15) *Tamarixia schina* Zuparko
- F2, F3 1.8–2.0 times as long as broad 4
- 4 Whorled setae of F1 reaching the top of F3, whorls of F4 reaching top of C2 (Fig. 17) *Tamarixia triozae* (Burks)
- Whorled setae of F1 reaching top of F4, whorls of F4 attach out apical sensillum (Fig. 20) *Tamarixia leucaenae* Bouček

Description of new species

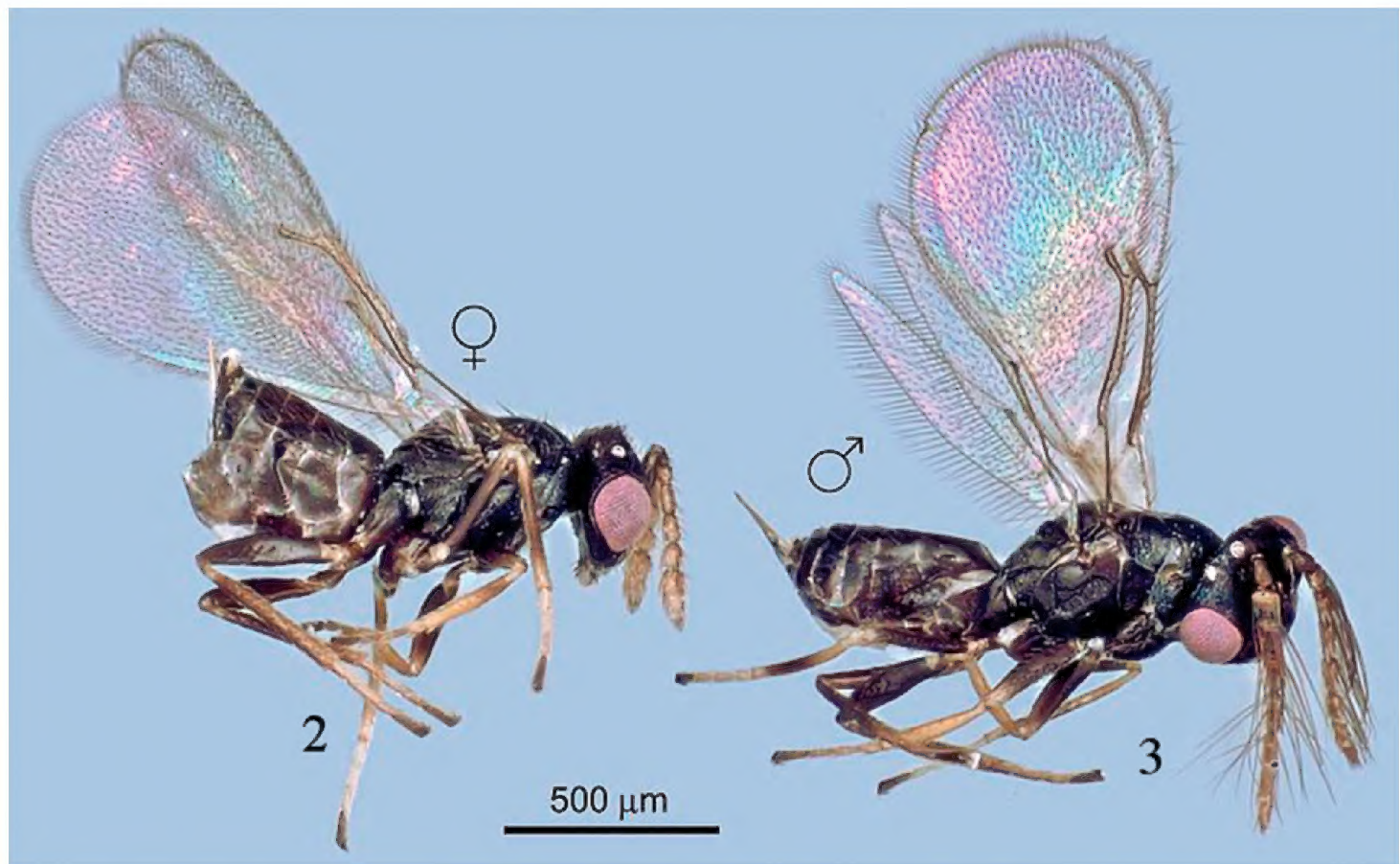
Tamarixia aguacatensis Yefremova, sp. n.

<http://zoobank.org/2E77279C-F3E8-4C9F-97A8-4329A33AC45D>

http://species-id.net/wiki/Tamarixia_aguacatensis

Figs 2–13

Holotype (female): MEXICO, Michoacán, Salvador Escalante, Ejido El Tarascon, 19°26'29.81N, 101°49'53.03W, 1,910 m, 2.iv.2012, G. González-Santarosa (deposited in TAUI). **PARATYPES** (same data): 3 ♀, 3 ♂ (CNIN); 1 ♀, 1 ♂ (USNM); 2 ♀, 4 ♂ (TAUI).

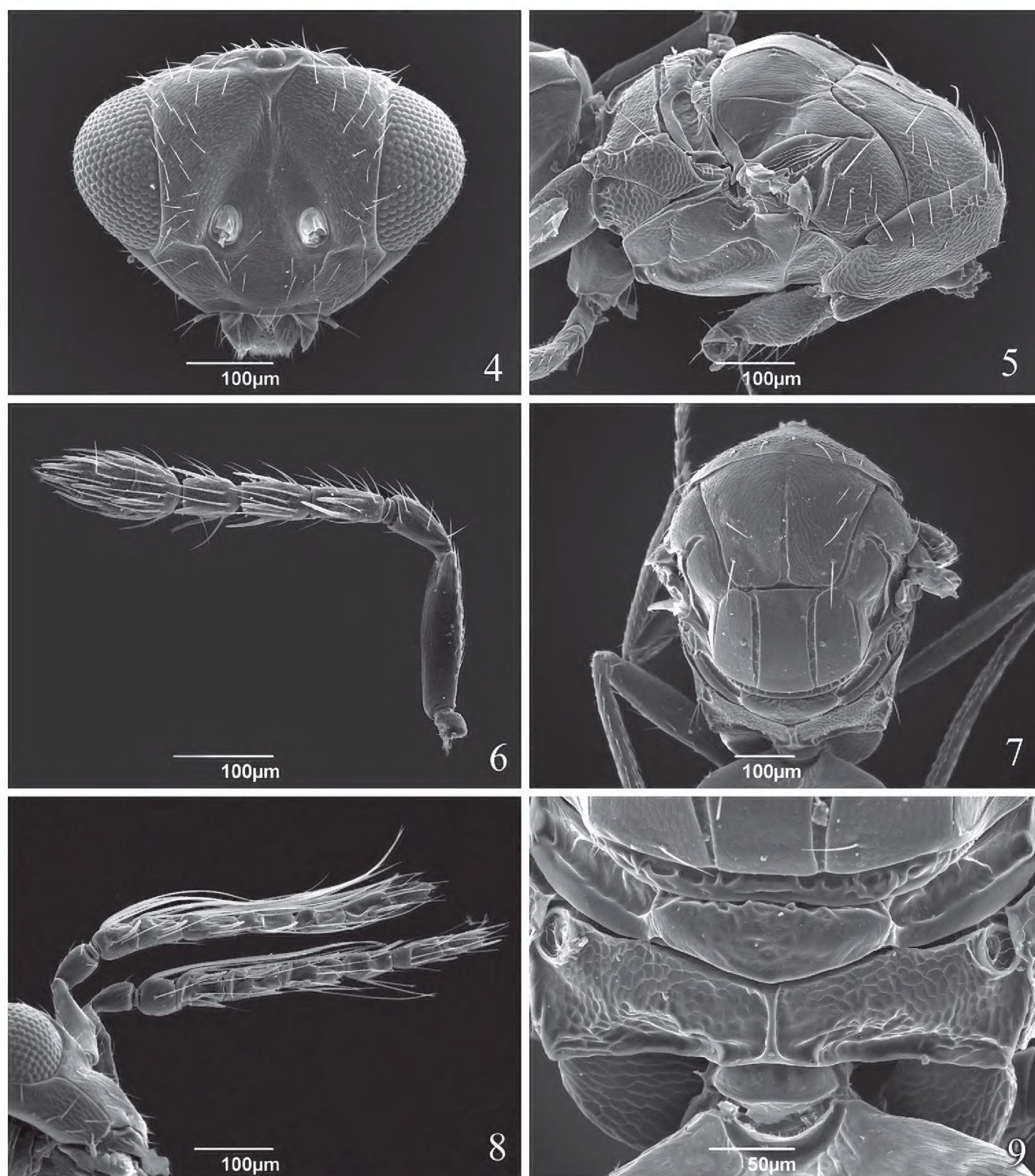


Figures 2–3. *Tamarixia aguacatensis*, female and male (habitus).

Description. FEMALE (Fig. 2). Body length: 0.85–1.04 mm; fore wing length: 2.07–2.94 mm. Body shiny black, eye pink; antenna yellow, scape black except yellow ventrally and apically; pedicel dark dorsally and basally, yellow-brown on ventral surface; flagellar segments and clava sandy yellow; tegula yellow; legs brown dark, coxae brown, trochanters brown, trochantelli yellow, basal and distal apices of pro- and meso-femora and tibiae yellow, and metafemur and tibia brown; tarsi yellow except apical segment brown. Metanotum yellow. Gaster brown. Wings hyaline, venation brownish.

Head 2.2 times as wide as long (Fig. 4). POL 2.0–2.2 times OOL. Face smooth; vertex, frons, areas near orbits and lower face setose. Malar sulcus present. Toruli slightly above lower level of eyes. Mandible with upper long tooth and several lower short teeth. Scrobes depressed and sutured (inverted V-shaped). Eye bare. Antenna (Fig. 6) with scape 2.3 times as long as pedicel, 1 discoid anellus, pedicel as long as F1 and F2 combined, F1 2.2 times as long as broad and equal to F2, F2 2.0 times as long as broad and 1.3 times as long as F3, clava 3-segmented, 2.3–2.4 times as long as broad and 2.4–2.6 times as long as F3.

Mesosoma. Pronotum short, with 8 marginal setae (Fig. 5). Mesoscutum 1.5 times as long as broad with an incomplete median line (0.63 length of mesocutum) and with 2 pairs of long adnotaular setae (Fig. 7). Mesoscutum with additional 2 pairs of short setae in the upper part in a horizontal row and 1 seta near notauli (Figs 5, 7). Mesocutum, scutellum and dorsellum finely reticulate. Scutellum with two submedian lines closer to each other than to sublateral lines, with 2 pairs of setae; first pair of setae in the middle of scutellum. Mesosoma in lateral view higher than the plane of propodeum and inclined at an angle less than 45 degrees from the longitudinal axis of the



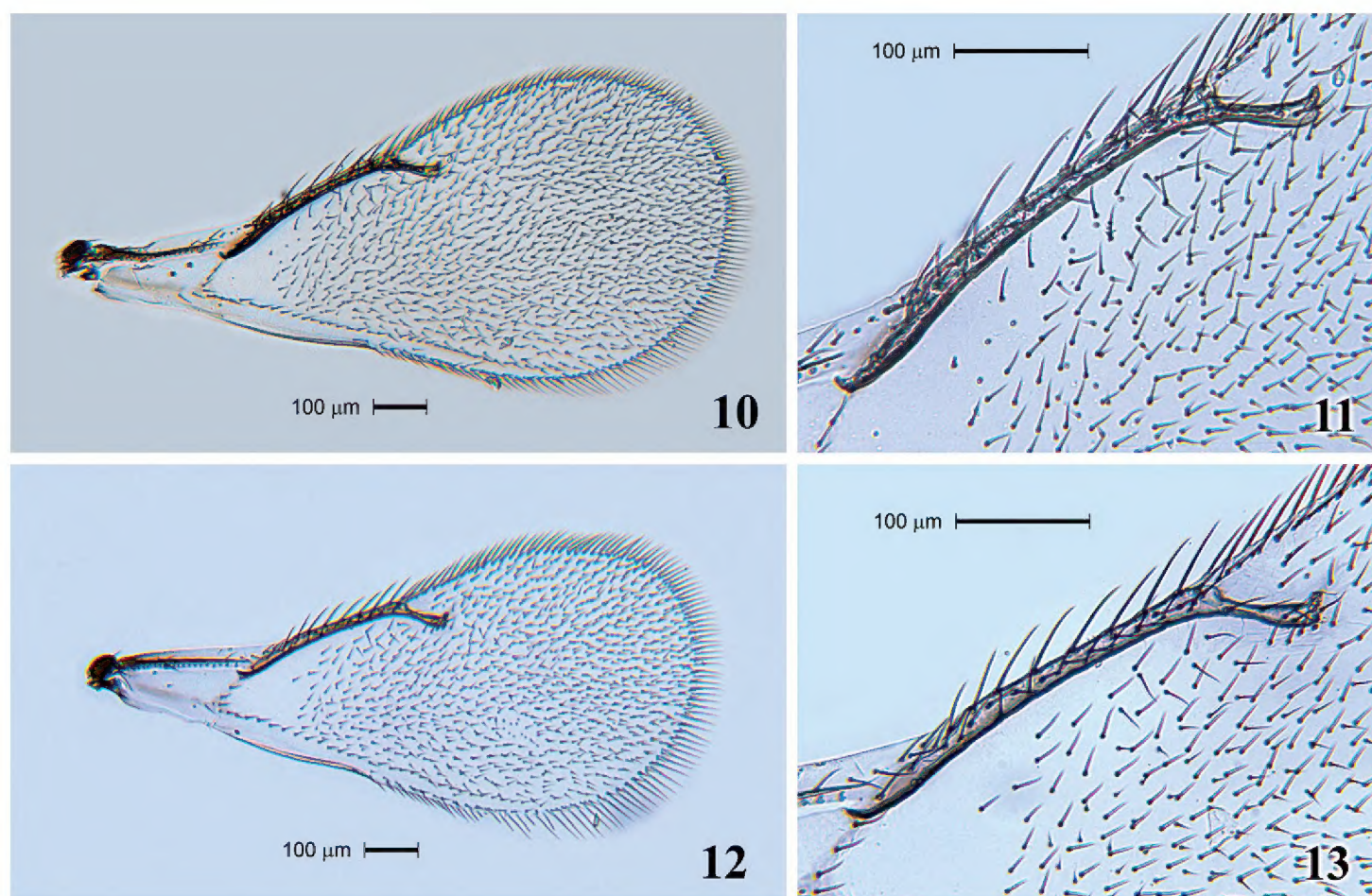
Figures 4–9. *Tamarixia aguacatensis*. Female: **4** Head, frontal view **5** Mesosoma, lateral view **6** Antenna **7** Mesosoma, dorsal view **9** Propodeum. Male **8** Both antennae on the head.

body (Fig. 5). Propodeum (Fig. 9) strongly reticulate, with a complete simple median carina; spiracle with a rim. Callus with 2 long setae in one row (Fig. 7).

Fore wing (Fig. 10) 2.6 times as long as broad. SMV with 1 seta. Speculum extending along half length of MV and closed. SMV 1.2 times as long as MV. MV with 8 setae (Fig. 11). STV 3.4 times shorter than MV. PMV absent. Hind wing acute at apex.

Gaster 1.16–1.27 times as long as broad. Ovipositor sheaths slightly visible (Fig. 2).

MALE (Figs 3, 12, 13). Body length 0.8–1.00 mm. Colour of body very similar to that of female except gaster with tergite 1 completely yellow. Antennal scape dorsally

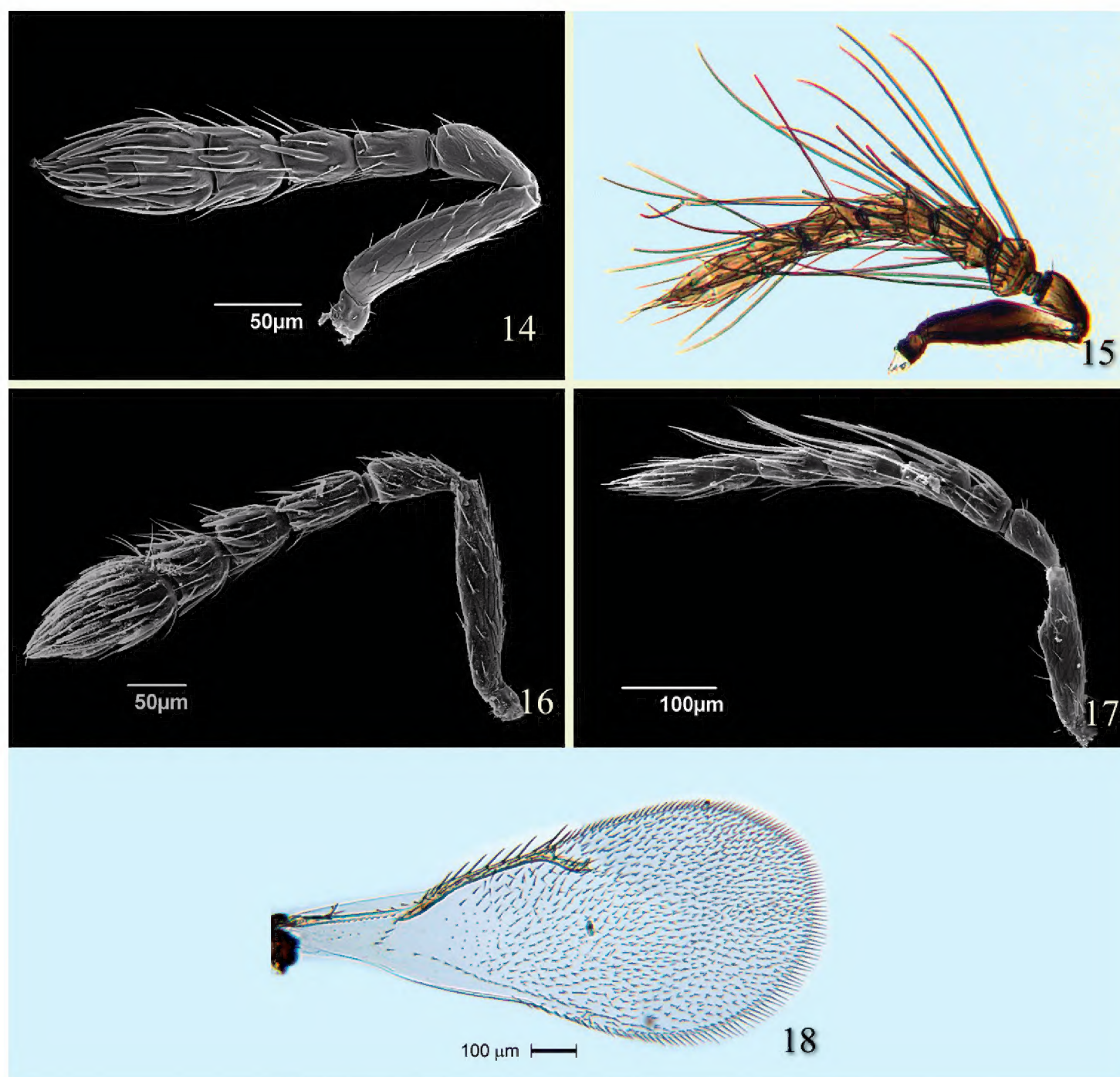


Figures 10–13. *Tamarixia aguacatensis*. Female: **10** Fore wing **11** Marginal vein with setae. Male: **12** Fore wing **13** Marginal vein with setae.

dark brown; pedicel, and funicle sandy yellow. Coxae of all legs brown, trochanters brown, trochantelli yellow, pro- and meso- femora brown except yellow at apex, metafemur and tibia brown, tarsi yellow except apical segment dark brown. Tegula yellow. Eyes pink. Ocelli white.

Head. POL 1.6–1.8 times OOL. Antenna (Fig. 8). Scape with ventral plaque about 0.2 length in the basal half. Pedicel 1.0–1.2 times as long as F1, F2 1.1 times as long as F1, F3 1.18 times as long as F2 and equal to F4, C1 equal to C2 and C3 1.2 times as short as C2. Four funicle segments with whorled setae; whorls of F1 reaching middle of F3, whorls of F2 reaching base of F4, whorls of F3 reaching tip of C3, whorls of F4 reaching middle of C2, whorls of C1 reaching base of C3, whorls of C2 reaching middle of C3, whorls of C3 reaching apical placoid sensillum. Scutellum smooth between submedian lines, and submedian and sublateral lines. Fore wing 2.1 times as long as broad (Fig. 12). Speculum slightly larger than that in female and MV with 9 setae (Fig. 13). Metasoma. Gaster 1.65–1.8 times as long as broad. Genitalia with two long longitudinal digital sclerites. Aedeagus very long, 2.3 times as long as gaster (Fig. 3). Parameres triangular with one long parameral seta.

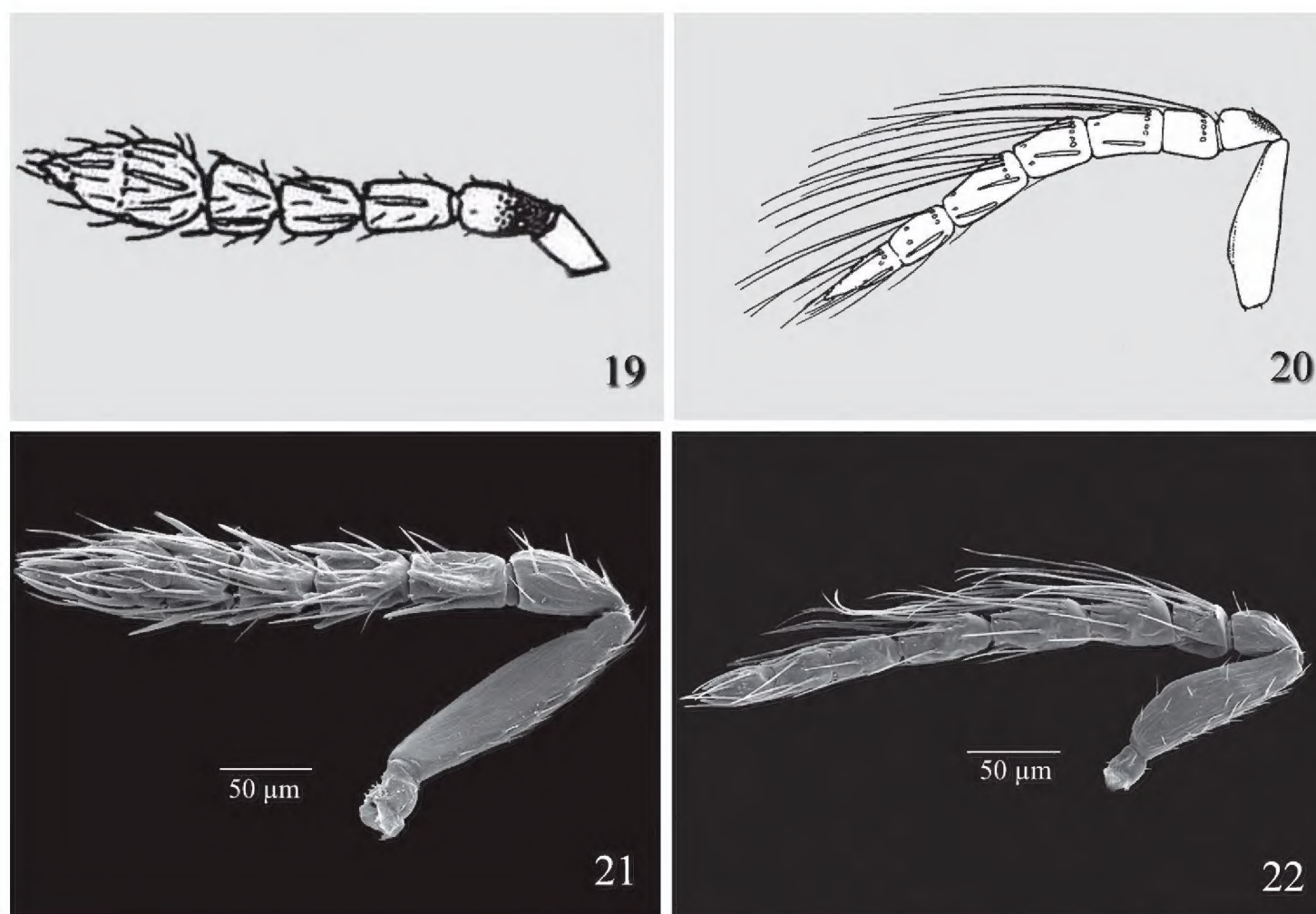
Diagnosis. *Tamarixia aguacatensis* resembles *T. leucaenae* (examined were two female paratypes (FSCA) with the following data: Trinidad and Tobago, Trinidad Island, “UWJ Field, stn. (Lab)”, on *Leucaena* sp., det. by Z. Bouček, 1988) from which it differs by the colour of the female: legs dark brown except coxae and trochanters brown, trochantelli yellow (coxae yellow in *T. leucaenae*); in addition, the female of *T.*



Figures 14–20. *Tamarixia schina*: **14** Female antenna **15** Male antenna. *Tamarixia triozae*: **16** Female antenna **17** Male antenna **18** Female fore wing.

aguacatensis differs from that of *T. leucaenae* in having F1-F3 2.0–2.2 times as broad as long and clava 2.4 times as broad as long (F1 1.7 times as long as broad, F2 1.4 times as broad as long, F3 subquadrate and clava 2.0 times as broad as long in *T. leucaenae*).

The female antenna of *T. aguacatensis* differs from that of *T. schina* (Fig. 14) as follows: F1-F3 2.0–2.2 times as broad as long and clava 2.3–2.4 times as broad as long (F1 1.8 times as broad as long, F2 1.2 times as broad as long, F3 transverse, and clava 1.8 times as broad as long in *T. schina*). The male antenna of *T. aguacatensis* differs from that of *T. schina* (Fig. 15, illustrated here for the first time) as follows: pedicel equal in length to F1 (1.5 times as long as F1 in *T. schina*), F1 and F2 equal, F2 1.2 times as long as F3 (F1, F2 and F3 equal in *T. schina*), clava 2.5 as long as F3 (2.0 times as long as F3 in *T. schina*), clava 2.0 times as long as broad (1.5 times as long as broad in *T. schina*). Additionally, the metanotum and propodeum are inclined much less in *T. aguacatensis* than in *T. schina*.



Figures 19–22. *Tamarixia leucaenae*: **19** Female antenna **20** Male antenna **21** *Tamarixia radiata*: **21** Female antenna **22** Male antenna.

Female of *T. aguacatensis* differs from that of *T. triozae* (Fig. 16) by in having F1–F3 2.0–2.2 times as broad as long and clava 2.3–2.4 times as broad as long (F1 2.0 times as broad as long, F2 1.7 times as broad as long, F3 subquadrate, and clava 1.6–1.7 times as broad as long in *T. triozae*). The male antenna of *T. aguacatensis* differs from that of *T. triozae* (Fig. 17) as follows: pedicel equal to length F1 (1.6 times as long as F1 in *T. triozae*), F1 and F2 equal to each other, F2 1.2 times longer than F3 (F1 subquadrate, F2 1.17 times shorter than F3 in *T. triozae*), clava 2.5 as long as F3 (2.2 times as long as F3 in *T. triozae*).

Female of *T. aguacatensis* differs from that of *T. radiata* (Fig. 19) in having F1–F3 2.0–2.2 times as broad as long, clava 2.4 times as broad as long (F1 1.6 times as broad as long, F2 1.5 times as broad as long, F3 subquadrate, and clava 2.0 times as broad as long in *T. radiata*). The male antenna of *T. aguacatensis* differs from that of *T. radiata* (Fig. 20) as follows: F1 and F2 equal to each other (pedicel equal in length to F1 in both species), F2 1.2 times longer than F3 (F1 1.4 times as short as F2, F2 equal to F3 in *T. radiata*), clava 2.5 as long as F3 (5.0 times as long as F3 in *T. radiata*), whorled setae of F1 reaching middle of F3 (reaching top of F4 in *T. radiata*), whorls of F2 reaching base of F4 (Fig. 8) (reaching middle of C2 (Fig. 22) in *T. radiata*).

The male antenna of *T. aguacatensis* resembles that of *T. psyllae* Yefremova & Yegorenkova from Yemen that was reared from *Trioza erytrea* (Del Guercio) (Yefremova and Yegorenkova 2009). In the former the whorled setae of F1 reaching middle

of F3 (reaching base of F2 in *T. psyllae*), whorls of F2 reaching base of F4 (reaching base of F3 in *T. psyllae*), whorls of F3 reaching top of C3 (reaching base of F4 in *T. psyllae*), whorls of F4 reaching middle of C3 (reaching C1 in *T. psyllae*).

The male antenna of *T. aguacatensis* resembles that of *T. dryi* (Waterston), reared from *Trioza citri* Laing in Kenya (Waterston 1922), from which it differs as follows: whorls of F4 reaching middle of C3 (not reaching C1 in *T. dryi*), whorls of C1 reaching base of C3 (whorls of C1 reaching 0.8 length of clava in *T. dryi*).

Tamarixia aguacatensis also resembles *T. flavigaster* (Brothers & Moran), described from South Africa from Psyllidae on *Calodendrum capense* (L.) (Brothers and Moran 1969), from which it differs as follows: mesoscutum with incomplete median carina, coxae brown (complete median carina and pale coxae in *T. flavigaster*), male antennal plaque about 0.2 length of scape (0.1 in *T. flavigaster*), whorled setae of F1 reaching middle of F3, whorls of F2 reaching base of F4, whorls of F3 reaching top of C3 (whorls of F1 reaching clava, whorls of F2 and F3 reaching base of C3 in *T. flavigaster*). Also, the species has a brown gaster (the gaster is almost yellow in *T. flavigaster*).

Distribution. Mexico.

Host. Known from *Trioza aguacate*, as a nymphal parasitoid.

Etymology. The species name is derived from its host, *Trioza aguacate*.

Tamarixia aguacatensis is the fifth known species of *Tamarixia* in Mexico. It can be distinguished from other congeneric species in the country by having two pairs of short setae in the horizontal row on mesoscutum (Fig. 7).

Acknowledgements

We thank Greta Hanako Rosas Saito and Jorge Valdez Carrasco (Colegio de Postgraduados, Carretera México-Texcoco Km. 36.5, Montecillo, Texcoco, Estado de México, Mexico) for their technical assistance with scanning electron microscopy, we also thank Serguei Triapitsyn (University of California, Riverside, California, USA) and John Huber (Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario, Canada) for their comments.

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